Chapter 3
Implementing IoT in India—A Look at Macro Issues and a Framework for Recommendations

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Abstract IoT is the latest technology on the block, promising to be a panacea for multiple maladies. India, too, is looking at IoT with palpable interest. In this paper, we look the four major stakeholders in India, at the forefront of adoption and use of IoT, namely the academia, startups, large manufacturers, and the government. A representative of each class of the stakeholders is studied in depth, and the problems that they are facing with respect to implementation are identified. It turns out that a substantial chunk of the macrolevel implementation issues faced by all stakeholders are situated on the threads of one-to-one interactions of these stakeholders, with collaboration and standardization issues enveloping these one-to-one interactions. We propose a framework for formulating solution recommendations for these macroissues and give an example of its use.

3.1 Introduction

The trigger for the three industrial revolutions of the past was technical innovations—the introduction of machinery, steam power utilization, mass production of goods, and growth of factories in the late eighteenth and nineteenth centuries; the technological innovations in steel, petroleum and division of labor in late nineteenth and twentieth centuries; and introduction of digital means for automation in manufacturing in the 1970s. According to industry experts and academic research, the next industrial revolution would be triggered by the Internet and connectedness.

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Industry 4.0, as the fourth industrial revolution is known as, in its current evolution is about leveraging automation and data for improving manufacturing efficiency and productivity. The broad areas of technology whose amalgamation is expected to give a fillip to Industry 4.0 are cyber-physical systems, cloud computing, human—computer interaction, Internet of Things (IoT), machine learning, and artificial intelligence. But it is not just manufacturing that looks to benefit from this basket of technologies—there is much talk and plans already underway for application of this technology basket to make life in general "smarter". These applications are henceforth collectively referred to as "smart", and the technology basket is referred to as "smart" technologies.

Governments all over the world are grappling with sustainability and environmental issues, which are to be balanced with overall improvements in standard of living and economic growth. With limited resources, commitment toward international pacts like the Paris Agreement 2020, improvement in average age, and the increasing population, the Indian government is looking at "smart" and IoT, especially, for plausible and sustainable solutions.

In the case of businesses, with Moore's law at play, the advancements in technology are coming about at a never before seen pace. Consequently, technology-driven strategic inflection points for businesses are occurring more rapidly than ever before. So far, the consequences for those who miss the technology inflection point bandwagon have been monumentally dramatic—cases in point, Kodak and Nokia. As Andrew Grove (1996) puts it, "a strategic inflection point is a time in the life of business when its fundamentals are about to change. That change can mean an opportunity to rise to new heights. But it may just as likely signal the beginning of the end."

The result is—there is plenty of excitement surrounding IoT and everything else "smart", and there is a global scramble to gain as big a lead as is possible. But for the kind of upheaval that this new evolution promises to create; there are not many example cases to go by. As time progresses, plenty of implementation issues keep on emerging. Given the connected nature of the technologies supporting "smart", these implementation issues can be broadly clubbed into two major groups:

a. Microlevel implementation issues, arising within a niche problem context in an institution.
b. Macrolevel implementation issues, which are not specific to a niche problem context and are faced by any IoT project within an institution. In other words, the implementation issues common to all IoT projects within the institution are defined as macrolevel implementation issues.

Another possible classification for the implementation issues is technological, managerial, and information management-related issues.

The motivation of this research has been to arrive at a clearer understanding of the macrolevel implementation issues. For the sake of simplicity and completeness, we classify the stakeholders in India looking to use IoT into four groups and study one of the more prominent first movers from each group. Next, we consolidate the issues that these first movers have faced. As it turns out, a substantial chunk of the macrolevel implementation issues faced by all stakeholders is situated on the threads of one-to-one interactions among these stakeholders, with collaboration and standardization issues enveloping these one-to-one interactions. We finally propose a framework for formulating recommendations for these macroissues and give an example of its use.

3.2 Classification for the Stakeholders

The following classification is proposed for the stakeholders involved in the move toward successfully implementing "smart" technologies for environmentally sustainable and profitable economic growth. This classification is based on the stakeholder's overarching mission and vision, as described below:

3.2.1 Academia—Fundamental and Applied Research and Development for Humanity's Progress

Academia in general tends to be at least 5 years ahead of the technology adoption curve elsewhere in the world. They are the input providers, sources of inspiration, and much-needed insights for both the industry and the governments. Researchers have their own set of implementation issues—research on issues where the problem is not well defined leads to plenty of false starts, and this adds to the already difficult issue of finding far-sighted investors to fund fundamental and applied research.

In India, institutions like IISc are working on innovative life-enhancing products and smart factory prototypes, in partnerships with major industry players and the government. For example, under the guidance of Prof. Dr. Rajesh Sundaresan at the Robert Bosch Centre for cyber-physical systems in IISc, a pilot project was implemented in the town of Aluva, Kerala, to understand electricity consumption patterns and provided personalized feedback to influence consumer behavior toward more sustainable habits (Robert Bosch Centre for Cyber Physical Systems 2017).

Other than this, UAVs and drones are another hot topic of research in academia. For example, Prof. Dr. Chiranjib Bhattacharya and his team at IISc are working on solving the problem of autonomous navigation of multiple drones, the solution to which will be applicable across a gamut of different fields from manufacturing to surveillance to logistics, even disaster management, and health care.

3.2.2 Startups—Breathing Life into Great Ideas in Niche Areas

In the last decade, India has seen a boom in the number of startups, many in the applied technology side such as e-commerce. The upcoming generation of startups is showing a gradual but marked tilt toward IoT-based applications (Ten emerging IoT startups in India 2017).

A report by management think tank Zinnov says that the IoT startup landscape in India is such that 67% of these startups are in the infrastructure layer, which includes hardware components such as infrastructure sensors, embedded chips, MEMS, actuators, modules, SIM card, and system design (Bengaluru ideal destination 2017). The report also states that the application layer accounts for 52% of the IoT Startups in India, it said. Based on use cases, the IoT landscape in India is segmented into:

- Industrial IoT
- Enterprise IoT
- Consumer IoT

Some Indian "smart" startups to keep an eye on are Boltt, Intugine, Carnot, Ather Energy. Startups, by their very nature, involve a considerable degree of risk with a fine balancing act with respect to idea and execution. Funding and short-sighted mismanagement of funds and lack of clarity in understanding the gap between consumer needs and the product on offer are some of the big causes of concern for sustained operations of startups.

3.2.3 Large Manufacturers—Improving Profitability with No Dent on Reputation

Large manufacturers, especially MNCs, have the capital, demand size, and overall economies of scale to actually go after Manufacturing 4.0 aggressively. Their approach to potential applications of "smart" technologies therefore differs widely from the approaches taken by startups.

Added to this is the fact that with the advent of communication technologies, the boundaries between industries are blurring very quickly. For example, Ford and General Motors now have taxi aggregators like Uber and Ola as competitors making a dent on their market shares. A similar struggle was highlighted by marketing guru Theodore Levitt long back in his seminal 1960 article "Marketing Myopia" for Harvard Business Review. He took the example of supermarkets eating into the profits of corner grocery stores in the USA. The same trend is seen each time a change in technology or consumer needs occurs—that is, whenever a strategic inflection point is encountered.

Given with its current stage of developments in the basket of technologies, whether or not the bet on Manufacturing 4.0 will pay off for the short-term is something that can be known decisively only as more use-cases emerge. The first movers, with massive capital and risk absorbance capacity on their side, have taken on the challenge to actually go ahead and force the development of these use cases in their respective organizations, the motive being to get as much experience as is possible, as soon as possible, so that the teething troubles can be sorted out, in anticipation of the more mature and stable future of the "smart" technologies.

3.2.4 Governments—Improving Quality of Life

Governments are similar to large manufacturers in the sense of the scale of problems that they are looking to solve, and the capital they have at their disposal. The range of applications is also much broader—from consumer-centric applications like smart electricity distribution to enterprise solutions like smart nuclear power plants. The motive, though, is more altruistic in nature, the approach more cautious because of the scale of impact on human lives, implementation often hindered by red-tapism, and negative lobbying as a result of conflicting interests of the stakeholders involved.

Nevertheless, the Government of India has decided that "smart" is indeed better—at least the emerging use cases strongly suggest so. For a country with a population of 1.3 billion and a diverse, expansive geographical terrain, any amount of efficiency in disbursal of services and manufacturing of products is to be seen as a welcome development.

3.3 Case Study 1—Academic Research

IoT-related academic research in India is being carried out extensively in research-intensive institutes like DST Delhi, IISc Bangalore (CSE, RBCCPS), and IIIT Hyderabad. One of the cases of the academic research project in IoT applications is discussed below.

Developing a framework to capture the effect of feedback system in electricity consumption data on energy efficiency in households
The motivation for this project is the fact that during the past five years 2010–2015, electricity consumption of Kerala had grown by about 33%. In addition to this, in the same five years, the cost of generating power has been increased by 31%, and it is likely to increase further. It is therefore essential for electricity utilities to actively interact with consumers and manage the demand growth. The project is taken up by Kerala State Electricity Board, RBCCPS, IIScs ECE and ESE departments, and Clytics Technologies. It focused on consumer engagement involving 25,000 consumers in the town of Aluva, near Ernakulam, in Kerala. The project lasted for 16.5 months.

The twin goals of the project were to understand the research challenges in building a consumer engagement platform prototype and to quantify the outcomes in the change of behavior of consumers based on the feedback given on electricity consumption patterns.

The experimental households could not all be instrumented with smart meters as that became too expensive. So, the team combined smart metering data from a set of just 30 representative households. They collected data on dwelling type, size of family, and appliance ownership. Also, they collected data on consumption patterns from about 3000 households, billing data from 50,000 households in a portion of Aluva. With this data, they did significant amount of modeling to arrive at personalized bimonthly feedback to 25,000 experimental households. The team compared the reduction in consumption in these 25,000 experimental households to that in similar number of control households.

The results of this pilot project were estimated to be around 1% reduction in consumption of the experimental group leading to an approximate reduction of 2.7 lakh units of energy, which amounted to approximately Rs. 14 lakhs at the cost of Rs. 5.26 per unit of energy. The average sale price for this domestic segment for the duration of the project is subsidized to Rs. 3.76 per unit of energy leading to Rs. 1.5 per unit. If the same project could be extended to entire Kerala, then the financial impact estimated is around Rs. 41 crores and subsidy amount estimate would be about Rs. 12 crores.

Thus, broadly, the challenges being faced by academia in India can be categorized as:

- **Lack of standardization**.
- **Funds**: There is often low fund flow for rigorous research.
- **Lack of proper recognition to research scholars**.
- **Infrastructure**: Internet connectivity and access are a prerequisite for some crucial aspects of the project discussed above. Another project run by RBCCPS uses drones. They raise the issue of lack of infrastructure and guidelines on charging points and airspace use for drones.
- **Lack of social behavior input in technology research**: There is next to no focus on the end user and their acceptance and reaction to the smart applications.
- **Effort Duplication**: Due to lack of a well-connected communication platform, problems arise in sharing expertise from different parts of the country.

3.4 Case Study 2—The Startups

Startups begin with great ideas to solve problems, but in general, their rate of failure is high. From the very few success stories observed in startups, all have a thing in common which is giving out of the box simple solutions to many complicated problems like what Uber, Airbnb, Dropbox did. Successful startup here would mean success both in terms of huge revenues reaped and the impact it created in the world.

IoT space is giving opportunities to people in all fields to come together and solve problems. For example for an IoT startup, we need electronics and signal communication experts, computer science programmers, design specialists for designing products, management experts to plan, organize, and control the various aspects of business. With these required synergies and scope of huge market in this niche area, a huge number of startups came out with great ideas for products and processes under the IoT ecosystem. One of the cases of these high-technology startups is discussed below.

Sensegiz

Sensegiz is one of the few startups, which realized the need for IoT wearables in "Track and Find" application. It has a good pitch, which says "Everyday, we spend about 55 min to look for things, which is 5 days per year." The problem Sensegiz tried to solve is long existent, which is tracking the objects lost or misplaced somewhere and the amount of time and effort put in searching for that object is enormous and people usually end up not finding the object they have been looking for. Sensegiz promises to give back this time, with small sensors that can be applied to any object (Abhishek Latthe 2013; Sensegiz; Sensegiz 2017).

SenseGiz Technologies Pvt. Ltd was founded by Abhishek Latthe (28) and Apurva Shetty (28) in February 2013 at Belgaum, Karnataka. They started up with the idea of developing IoT product to save the time in searching for objects.

When asked about what was the motivation behind starting up, the CEO Abhishek (2017) says, "It was always my ambition to launch a product based company. India is famous for a lot of software companies, but not too many product based companies in the hi-tech sector. Once I was sure that the ideas we had could be turned into successful products, we went ahead and launched the company."

This company has two flagship products—FIND, SAFR and then they also offer an entire range of customized IoT solutions for smart homes/offices and smart factories. FIND is the company's first product which was developed with the entire idea of solving the track and find problem for objects and pets as well. It is a small, square object with 38.6 mm on each side, and a small hole on upper right of it to attach as a key ring or any other such thing. The weight of the product is almost nothing with 6.4 mm thickness. It uses Bluetooth 4.0 to connect with Android/iOS app and the Bluetooth range is up to 160 ft. The battery inside this has a lifetime of six months. It basically has four modes of operations, namely active tracking mode, manual search node, phone protect node, and combined mode. The configuration can be set as per the need of the user.

SAFR is Sensegiz's second product, and it is designed and developed to assist users as emergency assistance provider, accurate fitness tracker, and sleep monitor. But the special feature that is included in this product, which sets it apart from the existing products in market, is integrated crash/fall alert system. It senses crash/fall events and sends an alert to user's emergency contacts through an app. It also has an emergency button that can send alerts with just press of it. It is primarily designed to save lives. It has a built-in battery that lasts up to 7 days and it is water-resistant.

COIN is another product, which is shaping the holistic IoT solutions at Sensegiz. It enables user to monitor opening and closing of doors and windows, also helps to know if someone knocks or any unauthorized person opens with the help of motion and vibration sensors. It can also detect leakages which may occur due to plumbing leaks, outside seepage, and condensate water overflow. As an application to smart home, the coin connects to user's home Wi-Fi network so that he/she can monitor and control the security devices using smartphone. This product can be termed as one-stop IoT solution with diverse applications in the field of real-time location system for tracking assets, security, and safety solutions for perimeter fencing and tracking people.

The successful startups in India, invariably, have had all of the following features:

- **Great Idea**: It was one of the first few startups which recognized the need to track and find objects in day-to-day life.
- **Great timing**: The success and sustainability of great, technologically disruptive products always depend on the timing of product launch.
- **Cost of production**: It is relatively cheap to produce IoT devices as the cost of basic raw materials required for this has become quite low and affordable. This makes manufacturers to come up with proof of concepts in lesser time and make prototypes of products faster. This makes them utilize more time for doing feasibility and market study.
- **Location decisions**: The location selection for IoT startup largely depends on resource availability and cost of production to produce in huge volumes. Based on the study, we observe that producers prefer to operate in a place where they can get loanable funds easily and place where they have an existing network, instead of producing in metro cities like Delhi, Mumbai, Bangalore, and Hyderabad.
- **Managerial decisions**: It seems not just the great idea, great timing, and good product make a successful startup, and they should all add up along with excellent managerial decision-making skills which include recruitment, marketing, supply chain management, financing, and strategy management.

The challenges faced by high-tech startups, as is evident from the study of the startup landscape in India with a specific focus on Sensegiz, are:

- **Pricing a tech product**: Four kinds of pricing strategies exist, we never know which one is profitable for which products. It has been a problem since for long time and there are no hard and fast rules for pricing. It all depends on many macroeconomic factors under consideration and the strategy the company chooses to follow.
- **Funds**: Like startups in any other industry, startups in IoT industry also face difficulty in getting funds. Almost all startups are producing their first phase of products using only their personal finances, despite many policies in place by Central and State Governments to support startups in India. It is also observed that startups tend to attract VC funds easily only if the founders are from top universities.

- **Infrastructure**: Smart devices relying on connectivity cannot make inroads in areas where Internet connectivity is either limited or completely absent. Hence, the lack of infrastructure serves a barrier to entry in potential markets.
- **Mentorship**: One of the prime reasons for startup exit is "lack of motivation." Founders get depressed and disappointed at all stages of starting up, when things don't go as expected. Often, there also exists a huge gap between what the customers want and what the startup founders want to build—the product may be extremely innovative, but its release and marketing is premature or unable to get its value across to the customer. So there is a need for mentorship and encouragement to startup founders.
- **Outsourcing**: In IoT startups, it is difficult to outsource any part of supply chain activities. The outcome of a startup's operations is either a niche product or service—there is a need to constantly interact with the customers and get feedback for betterment of the offering. So they can't outsource sales/marketing functions.
- **Expertise Management**: It is observed that when any startup is struck in any problem of any kind, be it technical, technological, financial, process-related, managerial, it starts solving the problem and finds solution in some time. The time taken to come up with a solution varies from one to another depending on the depth of intellect and expertise one has in that field. There is a need to manage the expertise, by developing a common platform which reduces the need to solve the same problems again and again by different companies.

3.5 Case Study 3—The Large Manufacturers

Manufacturing 4.0 prescribes that a smart factory should possess the following main characteristics:

(a) **Adaptability and Flexibility in Automation**: Mathias Schietinger, Head of Global Solution Center, Festo Didactic, states in an interview (2017) that the Festo smart factories are based on flexible automaton, implemented through:

   - versatile facilities which can be modified and changed depending on the demands of the market and production;
   - intelligent subsystems and components important for building such versatile facilities;
   - "Plug and Produce" feature to speed up the re-configuration of production systems;
   - flexible logistics solutions (autonomous robots for example) to connect the facilities.

   The factories of the future would thus be ones that can easily switch between project, job, batch, line, and continuous type of processes.

(b) **Resource efficiency**: Resource wastage, non-optimal inventory, and low productivity are often sources of cost increase in factories. Manufacturing 4.0 aims to reduce this through predictive analytics and connected intelligent value chain process.

(c) **Ergonomics**: Manufacturing 4.0 mandates a significant automation in many processes and constant reliance on intelligent machines. As a result, the physical design and usage characteristics of these systems should be such that they are intuitive to understand and operate, mitigate health disorders caused by stress that results from constant use.

(d) **Integration of customers and business partners in business and value processes**: To allow maximum benefit to emerge from integration and networking in the value chain.

The issues faced by large manufacturers in operationalizing smart factories are significantly different from small players due to the scale of operations involved. One case from the industry is illustrated below.

GE

GE has been among the first manufacturing giants to realize the power of data. Further, they possess decades of historical operations data of the life cycle of their products, the bandwidth to implement Manufacturing 4.0 at beneficial economies of scale and scope, as well as relevant in-depth mechanical engineering know-how to aid the development of robust big data analytics and machine learning-based algorithmic solutions. The company is banking heavily on IIoT, as is evident by the statements on its Web site, "IIoT is driving powerful business outcomes by enabling predictive analytics, raising efficiencies, and preventing cyber-attacks."

The GE Digital Suite is a basket of general purpose, industrial Internet of things (IIoT)-based software services to facilitate the adoption of Manufacturing 4.0 in any discrete or process-based manufacturing facility. The goal is to offer asset performance management, service management, and a full life cycle of industrial optimization, along with security management. They offer the following platform and software as services to their customers:

- **Brilliant Manufacturing**: The aim of brilliant manufacturing software suite is to build factories that are self-aware through the real-time interaction of machines and computers. The GE Web site describes it as "software that enables you to predict, adapt, and react more quickly and effectively than ever before." GE opened its first brilliant factory in Pune, India, recently (Brilliant Manufacturing).
- **Digital Twins**: The digital twin is a virtual clone of a real machine that lists all its past and current state variables at the click of a button. An example of the utility of the digital twin is that it makes predictions regarding the need and time for servicing available for ready reference for the site executive, thus giving them sufficient head start to plan out maintenance operations in a more efficient manner.
- **Predix Industrial Internet Platform**: This is the concept of Internet of Things, as applied to the industrial setting. It is a cloud platform as a service, which hosts many efficiency and operation streamlining utility applications, and a DevOps environment to allow consumers to build, test, and deploy their custom apps (Olavsrud 2016).

The benefits from the resulting optimization, as stated on the GE Web site, have been noteworthy. They note a 20% increase in recovered capacity, 20% decrease in inventory, and 10–20% reduction in unplanned downtime.

A close look at news reports in the 3rd quarter of 2017 about the financials and leadership reshuffles in the company paints a different picture. The higher-ups do not seem to be happy with the progress of GE Digital—but it seems to be more of an issue with vision formulation, goal time setting, strategy implementation, and cultural issues—with GE's traditional six sigma approach being more about slow and steady, but IIoT mandating fast and agile.

From discussions with sources in the company and published interviews of the GE leaders, the following broad issues were apparent in IIoT implementation:

- **Compatibility issues**: The communication mechanisms and data formats used by sensor devices sourced from different vendors vary widely. Therefore, significant attention from all stakeholders is needed to generate consensus for the formulation of standard protocols for the pre-processing of raw data generated by the sensor devices to a consistent format, and for the automation of communication between devices.
- **Problem definition**: For now, before the use cases develop further, IoT and smart manufacturing are case-based implementations. For a behemoth like GE, accordingly, each physical implementation demands a customized data analysis code. Hence, the guidelines toward building a truly general IoT software platform will need to ones that constantly evolve along the way as the industry use cases mature. Often, a broad problem statement is defined—its execution needs the formulation of multiple R&D-intensive subproblem statements that cut across diverse streams like robotics, computer vision, organizational behavior, industrial design, and materials engineering (The CSO Internet of things survival guide 2017).
- **Infrastructure**: An interview with GE Digital CIO Mrs. Asha Poulose Johnson brought up this issue. She held the opinion that technology in any form is not really a problem for a giant like GE. It is the infrastructure in the country, like Internet connectivity and power transmissions grids, that they face the maximum trouble with. She asked for efficient renovation and maintenance policies as support from the government.
- **Security at the intersection of IT, IoT, and OT integration**: GE Predix is a PaaS platform that is intended to host sensitive information of multiple clients, many of whom can be competitors. It is also possible that unscrupulous elements can gain access to areas not intended for them. This requires multiple layers of security checks, modular architecture design, and access barriers. Other than this, the low-cost sensors in use today, in enterprises, are often consumer devices like cameras and microphones. These have low-computing power and less security layers embedded in them compared to higher computing power devices, making them vulnerable to exploitation by hackers—the distributed denial of service attack on Dyn was carried out using cameras and not computers. Thus, what is hackable is constantly evolving, with predictions about chip-level hacks being made (Santarcangelo 2017).

- **Risk Management for personnel**: GE Global Chief Information and Product Cyber Security Officer Nasrin Rezai pointed in a recent interview that the manufacturing facilities are no longer isolated environments, they are highly networked. Earlier, cyber-attacks would render immobile devices like computers useless. In a manufacturing facility, a cyber-attack on the working of autonomous robots and assembly lines carrying toxic material like nuclear waste can have disastrous, life-threatening consequences. Therefore, there is a need for developing robust security drills, risk management processes, and protocols to be following in such situations by all affected personnel—both from IT and from manufacturing departments (Nadeau 2017).
- **Repurposing of Existing Manufacturing Equipment**: Many large factories still run on parts that are multiple generations old. Integrating them into the security perimeters of the connected, smart factory can often prove to be challenging. The need of the hour is to optimize manufacturing protection, detection, and response capabilities, as stated by Ms. Nasrin Rezai.
- **E-Waste Management**: The regulations on e-waste disposal vary widely from country to country, from extremely stringent rules to no rules at all. Waste management can be a time-consuming and costly affair in the production value chain of large manufacturers (Bhaskar & Turaga 2017; E-waste (Management), Rules 2016).

3.6 Case Study 4—The Government

Governments, especially in the developed and developing nations, are looking forward to "smart" as a much-needed panacea to many of their problems. The Indian Government is already considering smart cities, smart electricity grids, smart railways, smart water distribution, etc. The case of the railways is considered in more detail below.

Smart Railways

Railways rely about as much on information flow as they do on physical assets. They can be intercontinental networks spanning across oceans, carrying billions of people, and material every day. In 2012–13, 23.07 million people were using the Indian Railways per day, on an average. As a result, it is among the most interesting and complex ecosystems where "smart" can be applied (Smart Railways Market by Solution, Component, Service and Region 2016).

A market research report by the firm MarketsAndMarkets gives the following broad classification for the solutions currently being looked at to make railways smart,

- Passenger Information System
  - Multimedia information and entertainment solution

  - Network connectivity solutions

- Freight Information System
  - Freight operation management solution
  - Freight tracking solution
- Advance Security Monitoring Solution
  - Video analytics
  - Integrated security solution
- Rail Communication System
  - Ground-to-train communication solution
  - Train-to-train communication solution
- Smart Ticketing System
- Rail Analytics System

The current plan of the Indian government is to create:

- Smart coaches
- Smart railway stations
- Smart tracks
- Smart passenger management systems
- Smart maintenance systems

Even before the planning and implementation phases can start, the following issues are staring the government in the face:

- **Aging Infrastructure**: The fight is omnipresent, with the resources on hand, which should deserve first attention—the more expansive maintenance of the already crumbling existing infrastructure or the more costly and less expansive upgradation to "smart", in the backdrop of more than nine deadly rail accidents in 2017 alone.
- **Social Behavior**: Getting people accustomed to "smart" devices, both operators and end beneficiaries can a challenge due to diversity in education levels, age, and inertia toward accepting change, culture, and group habits.
- **Maintenance of IoT Devices**: Indian Railways network is huge, spanning the entire breadth, and width of the country. As a result, the maintenance of already deployed sensor devices is a potential problem.
- **Continuous Demand**: Railways is the most prominent means of transportation for a large cross section of Indians. Therefore, halting services on strategic spots for upgradation purposes is often extremely difficult to schedule.
- **Administrative Lag**: Economists often allude to three kinds of lags in the economic policy before any worthwhile change can occur and start producing results. These lags are:
  (a) Recognition
  (b) Decision
  (c) Implementation

(d) Effectiveness

A thorough scouring of news reports, high-level talks, current implementation progresses of proposed projects, and lethargy of non-creativity in proposals of new, potential applications suggests that the policy lag framework can be used to analyze the implementation issues being faced by the government as a stakeholder.

3.7 Common Macroissues—The Interaction Genesis Theory

A cursory glance at the specific cases of each of the four stakeholders highlights the following common list of macrolevel implementation issues:

- Regulatory policy—data ownership, privacy, collaboration, fair competition
- Social behavior
- Infrastructure
- Maintenance of IoT devices and e-waste management
- Ergonomics—human–computer interaction (HCI), training and education (ILC), usability ("standards are safe"), safety, and workplace risk mitigation
- Inter-device communication standards
- Engineering Standards

The genesis of most of the issues listed above is from the interactions among the stakeholders. For example, regulations are a by-product of the interactions of the large manufacturers and government. These interactions are succinctly summarized by the model proposed below (Fig. 3.1):

Any sustainable strategy to tackle many of the common macroissues will therefore involve *collaboration* between at least two of the four stakeholders, also among different parties within each category of stakeholders. We therefore propose that the above model be used as a framework to come up with any solution recommendations—so that the interests of all involved stakeholders are secured.

The environment for implementation of the recommendations derived from this model will need to involve a national-level consortium of representatives from all four categories of stakeholders. To ensure faster and efficient consensus formation on solution recommendations affecting less than four of the stakeholder categories, sub-consortiums can be formed on a case-by-case basis.

We also observe that any collaboration on solution recommendation for the common macroissues affecting the stakeholders will need to solve some degree of *standardization* to ensure smooth operationalization. Thus, the model envelope includes standardization and collaboration as key characteristics. These can themselves be used as solutions or as the starting point for the formulation of more pinpointed solutions.

3.8 Model to Recommendations—An Example

For the case studies analyzed above, we recommend the following solutions, using the framework proposed above (Fig. 3.2).

Within the umbrella of each recommendation for any given two-way interaction, the solutions can be further refined. For example, to solve the issue of e-waste management, both relevant infrastructure and regulatory support are required. The amount of e-waste from IoT-based applications will grow exponentially as time progresses. There is a scope for creating an excellent business out of this e-waste management issue, which would be based on business model of collecting e-waste from all stakeholders, filtering out the toxic substances out of it and extracting the portion of useful metals like steel and aluminum from it and sell them back to producers, who can utilize them for productive use. So, there is a need on part of electronic goods producers also, to take e-waste as a serious concern and they should voluntarily participate in EPR program. EPR is Extended Producer Responsibility framework across the world which says that producers of these products should take the responsibility of end-of-life management of their products. They should set up collection centers and ensure that the waste collected is recycled and disposed in an environment-friendly manner. The guidelines for these EPRs should be given by a government panel in consultation with academia to ensure that a specific level of hygiene and standards is maintained.

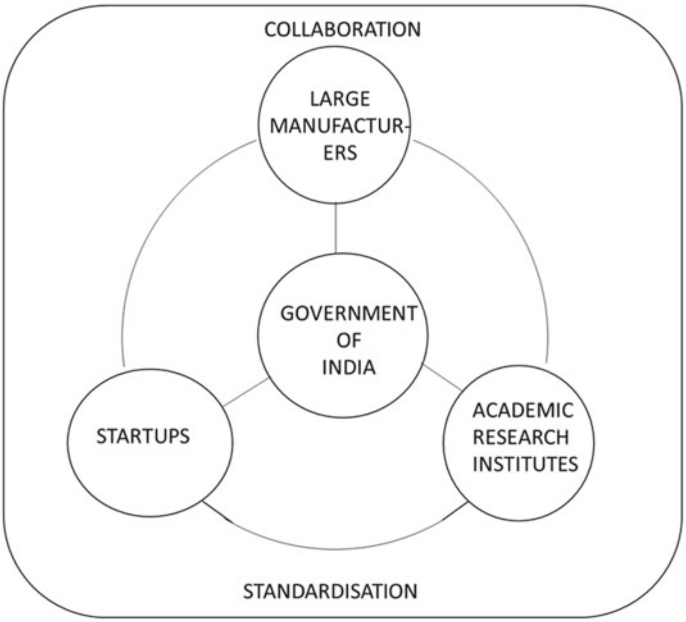

Fig. 3.1 Stakeholder interactions model

Another example is the issue of lack of social behavior input in technology research, pointed out in then the academic case study discussed above. The project team points out that there was a need of a social scientist in the team, to have good customer engagement in the project. As the project is to understand the behavior change in consumers based on the feedback given, the effective customer interaction would have helped them to get better insights into their electricity consumption patterns. Having effective customer connect would also help in understanding additional problems faced by them related to electricity, and there is a scope to give holistic solutions effectively and efficiently. There is a need for technology sciences and social sciences to go hand in hand. This issue can be solved by collaboration between different academic institutions, one specializing in social science and the other in technology, along with startups like SocialCops that collect social data from the grassroots (Socialcops).

For the issue regarding the removal of effort duplicity, again, collaboration is suggested as a solution. It has been observed in all case studies above, people around are trying to solve same or similar problems but at different places and in different points of time. Thus, we recommend that a common platform should be created, where the problems that are faced frequently, and the proposed solutions for the same can be discussed. It should ideally start with academia-industry collaboration. An organizational structure should be developed and regular meet-ups should be

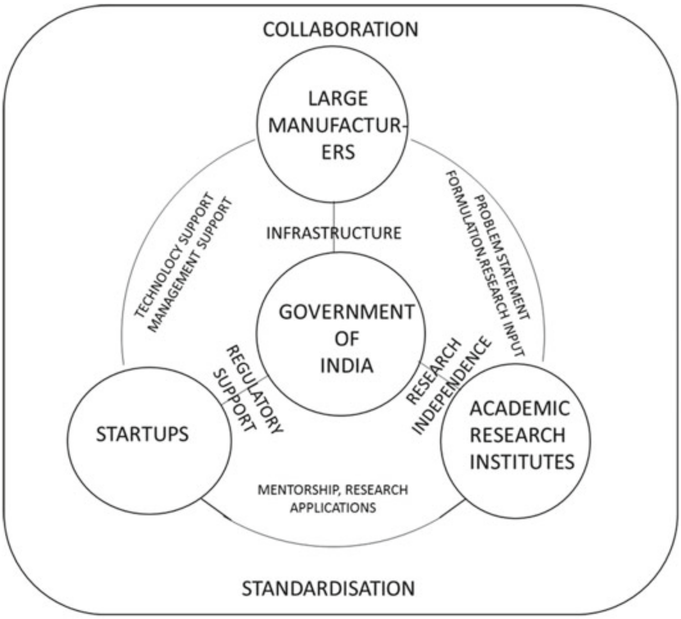

Fig. 3.2 Recommendations for macro issues of the stakeholders studied

organized for sharing new developments and for brainstorming sessions on attacking each new set of problems evolving every day.

3.9 Conclusion

This paper identifies the existence of four major stakeholders in India in the IoT practices space, namely the academia, the startups, the large manufacturers, and the government. These groups are also the influencers for the adoption of technology. For each of them, a representative case has been chosen and a detailed study has been done to identify the challenges that these stakeholders face. From the analysis, it turns out that there are a set of common problems for all the stakeholders, and that these problems need to be tackled together as these issues invariably arise out of the interactions of the entities within each stakeholder groups or between the stakeholder groups. So, *collaboration* and *standardization* are suggested as the way forward for tackling implementation problems in the IoT space. The paper proposes a framework for formulating solutions to the macroissues to ensure that the interests of all stakeholders are taken in account, and long-term, holistic, and sustainable solutions can be developed. We also give an example of the application of this framework to the specific issues identified in the cases studied.

3.10 Limitations and Further Research

One of the limitations of this paper would be that the proposed framework is India specific as the stakeholders identified are India specific. Further research could be taken up in two directions. One would be by collecting data and qualitative interviews from a good number of cases for each stakeholder identified and then generalizing the proposed framework for recommending solutions. The other direction for further research would be to test the effectiveness of the recommendation generation strategy proposed by this paper. This could be done by collecting data on inputs, outputs, and processes.

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